CLIMATE CHANGE FINANCE:
Providing Assistance for Vulnerable Countries

TESTIMONY PREPARED FOR THE HOUSE FOREIGN AFFAIRS COMMITTEE'S SUBCOMMITTEE ON ASIA, PACIFIC AND THE GLOBAL ENVIRONMENT
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PREPARED BY:
REDMOND CLARK, PhD
Chief Executive Officer
CBL Industrial Services
760 Industrial Drive, Cary, IL 60013
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drred_tdj@hotmail.com

INTRODUCTION

I do not come before this committee as an operating public policy-maker, although I have served in that capacity in the past. I have received extensive training in climatology and in climate model development; I have developed or supported the development and evaluation of hazard warning systems for large urban areas; and I have performed extensive hazard risk assessments for large areas of the US, including hurricanes, riverine flooding, droughts and low flows. In addition, I have performed a series of analyses regarding interaction between extreme environmental events and toxics management. In short, I would not presume to tell this committee that I am fully versed in the foreign policy and treaty complexities associated with climate change. But when policy is converted into a specific action plan and funded, someone with my background may well be responsible for implementing those plans.

With that background in mind, this committee has gathered to discuss adaptation funding for developing nations. In particular, the committee wishes to consider finance mechanism and governance issues associated with climate change adaptation and mitigation funding provided to vulnerable countries. I would like to offer a few thoughts and observations regarding US and international options for vulnerable/developing nation adaptation support.

ADAPTATION

When we speak of adaptation, there are a number of different meanings that are used in science and policy circles. For the purposes of this testimony, I use the term "adaptation" as the initiatives and measures necessary to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Within that meaning, I use the term "mitigation" to refer to efforts to reduce the impact of climate changes. Such efforts do not include any consideration of the costs, means or methods for reducing the amounts of GHG emissions into the atmosphere.

"Adaptation" sounds straightforward, but it is not. Natural climate is variable, both over space and over time. If we consider historical climatic data, we see that the world has experienced markedly different climates over time (ice ages, climatic optimums, etc). At any given location, we expect to see wet and dry years, as well as warmer and cooler years. Wealthier nations have developed a host of technologies for dealing with extremes of climate variability, especially when those extremes threaten human and natural systems. We call those extreme events natural hazards (floods, hurricanes, droughts, infestations, etc), and although the management alternatives will vary by hazard, the methods for dealing with those hazards have several common threads:

- We study the magnitude, (size, impacted area, severity of conditions) and frequency of those events for each location over extended periods of time
- We define a series of options that will manage or mitigate the effects of the specific natural hazard (A Range of Choice)
- We assess the benefits, costs and effectiveness of each option, and design a program or plan to manage risk at an acceptable cost. Such evaluations typically include consideration of fiscal, social and environmental impacts

Implementation of such a hazard management plan here in the US typically involves some combination of various structural (dams, levees, flood barriers, etc) and non-structural (land use restrictions, building codes, hazard insurance) options. The plan is based on a careful study of local conditions, past climatic data and historic hazard events, not to mention the current extent and condition of local human and natural systems. Although protection will vary based on the selected management tools and hazard characteristics, typical domestic hazard mitigation plans are designed to minimize losses during events with a recurrence interval in the range of 100 to 500 years. In short, based on a *known* range of conditions, we selectively manage risk.

"Climate change" means that we no longer face a known risk. If local precipitation and temperature patterns change, they will change the magnitude and frequency of previously understood hazards. Climate change therefore requires *all* nations, communities and individuals to adapt to a new, partially unknown distribution of hazards. It means that developed nations will have to potentially modify past efforts to manage environmental hazards, and it increases the risks of unprotected and partially protected populations in developing nations.

CLIMATE FORECASTING UNCERTAINTY

If an understanding of the magnitude and frequency of natural hazards for any location is a key element in mitigating risk, and since climate change suggests that such risks will be altered for all places on the globe over time, perhaps the first and most relevant question we might ask is: adaptation to what? The IPCC (2007) acknowledges that there are substantive forecasting inconsistencies between a host of climate modeling and forecasting efforts, but the IPCC research in aggregate suggests that human-caused climate changes are already upon us. The consolidated IPCC climate forecasts for the upcoming century suggest that continued global warming is all but certain, and they suggest that the climates of vast areas are expected to change, with altered precipitation and temperature distributions forecast for many parts of the globe. Those "altered distributions" may translate to more frequent and greater magnitude natural hazard events (including floods, droughts, heat waves and hurricanes) globally.

To date, there is no global agreement on limiting carbon emissions, so one of the primary model inputs – the levels of GHGs stored in the atmosphere - is expected to increase, but by an unknown amount. The absence of any global GHG emission controls also means that the forecast magnitude and frequency of expected impacts (read environmental hazards) is also substantively uncertain. A quick review of the IPCC AR4 underscores that fact, as 6 emission scenarios have been developed to provide a range of expected temperature impacts based on the global release rates of GHGs (See Figure 1). Depending on the amounts of GHGs released to the atmosphere, the combined models suggest that we could see a 15-fold range of temperature changes (increases from one to fifteen degrees Fahrenheit) over the next 100 years depending on GHG accumulation rates in the atmosphere.

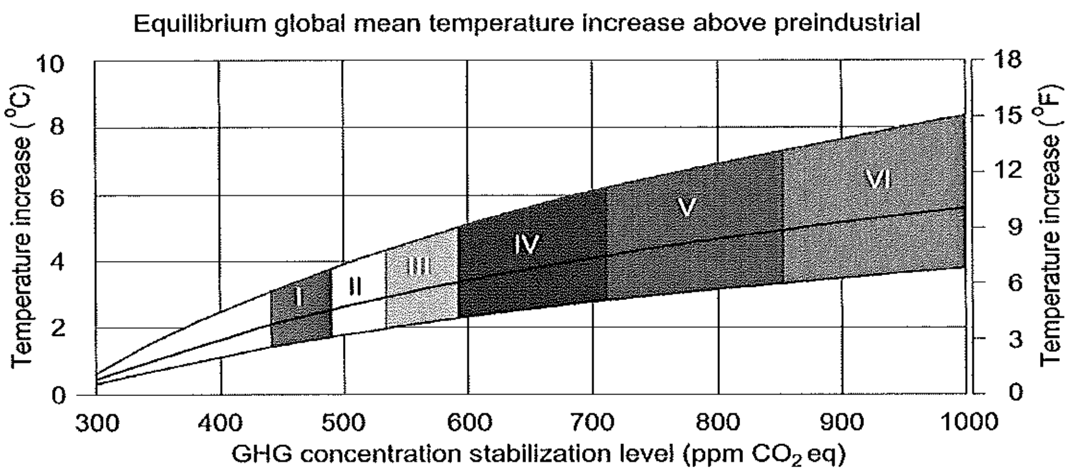

Figure 1: Forecast Changes in Global Mean Temperature with Modified Levels of Atmospheric GHGs. Source: IPCC AR4, 2007

Similar efforts to forecast changes in the amounts and timing of precipitation reveal multiple relationships between atmospheric GHG levels and precipitation distributions, and the latest IPCC published modeling efforts suggest that higher levels of GHGs will substantively change precipitation amounts and extreme event frequencies. Without hard information on atmospheric GHG levels in the future, we will not be able to fully and accurately forecast global climate changes. For any given location, this also implies that we will not be able to forecast natural hazard magnitudes and frequencies, and those forecasting uncertainties will limit the utility and reliability of existing hazard management programs (including sea walls, levees, coastal barriers, dams, insurance, warning systems, etc). **Our current forecasting tools cannot give us a clear sense of the climatic conditions that will drive adaptation efforts.**

MODEL SCALES DO NOT SUPPORT LOCAL HAZARD MANAGEMENT EFFORTS

In addition to model input uncertainties, there is a second model-related issue: the models used to produce the IPCC forecasts are at a scale too large to support local hazard management programs. At present, the model scales may use model cell sizes that are substantially larger than useful for hazard identification and mitigation. For example, typical global circulation models use grid sizes that range between one and five degrees of latitude and longitude (4,400 to 111,000 square miles in size at the equator). This is the size range equivalent of the state of Connecticut (4,400 square miles) to Arizona (113,000 square miles). In many areas of the world, there are multiple sets of climatic conditions present within a single cell. (For example, the state of Colorado has arid, semi-arid, humid mid-latitude and alpine climates within its borders.) In addition, local conditions will act to amplify or suppress changing climatic conditions. (For example, areas now served by streams fed by glaciers will experience significantly different riverine flooding hazards if the glaciers melt away and precipitation patterns change. Both are predicted in the IPCC AR4.) Forecasts of changing climate at the individual cell level do not necessarily translate into useful information when trying to understand local environmental hazards. There are significant efforts under way to regionalize those models, but useful, long-term regional forecasts appear to be at least a decade away. **Our forecasting tools do not provide meaningful, localized data that would be useful in many hazard management efforts.**

LOCAL CLIMATIC DATA COLLECTION EFFORTS

Many less developed countries do not have the resources to develop and manage climate data collection programs that could be used for local hazard model development, nor do they have regionally representative historic records of climatic data. In developed nations, engineering design efforts are typically based on local historic climate records and hazard records/experience that extend over the 50 years or more. This allows a project designer to identify the probability of various extreme events, and allows the designer to select a risk management target for any hazard mitigation program design. For example, a dam designer might want to develop a capacity to manage a 100-year drought and a 100-year storm. Extreme high and low flow records along with historic climate records allow the project designer to develop a frequency distribution of events that will define the performance standards for a hazard mitigation program (the height of the dam, the size of the spillway and the size of the water supply that can be safely distributed from the reservoir). In the absence of historic data, information can be transposed or modeled from more distant instrumentation, but such efforts degrade the accuracy of a local natural hazard magnitude and frequency analysis.

Forecast uncertainties, difficulty in translating global-to-regional model outputs and local data limitations all reduce the quality of the information that is the foundation of a natural hazard mitigation/adaptation analysis.

THE SIZE OF THE ADAPTATION PROBLEM

How large is the adaptation problem? The numbers vary dramatically depending on the estimation processes used. For example, the following estimates have been prepared by a number of respected individuals and agencies around the world:

- World Bank (2006) $9 to $41 Billion per year
- Stern (2007) The Stern Report: $4 to $37 Billion per year
- UNDP (2007) Human Development Report 2007/2008: $47 to $109 Billion per year
- Oxfam International (2007): >$50 Billion per year based on a low warming estimate (2 Degrees C)
- UNFCCC (2007): $26 - $67 Billion per year by 2030
- Climate Works (2009) Project Catalyst: $15 to $30 Billion per year through 2020, $30 to $90 Billion per year after 2030.

The wide (ten-fold) variances in estimates ($9 to $109 Billion per year) are based on a number of factors, but I would call attention to four observations:

- Each report assumes a different discount rate in order to set a present day value for anticipated losses from climate change, and many analyses use a very low number (less than 2%), which tends to variably overstate the present value of future damages and the possible size of the problems we face. This may distort both need estimates and the necessary timing of responses.
- Each study looks at a different universe of impacted systems
- All studies include variably accurate assemblages of analyses regarding the current conditions of environmental and economic systems in each developing nation, not to mention incomplete data regarding the presence and status of natural hazard management/mitigation systems
- There is no clear climatic path ahead. For reasons enumerated earlier in this testimony, policy-makers can only make an educated guess at what might lie ahead, and their range of climate choices is exceptionally broad.

We do not have a clear definition of the adaptation problem, and any attempt to get a better feel for the problem magnitude will be further confounded by the reality that economic development and adaptation are intertwined with each other. For example, poor housing quality will be more readily damaged in a storm when compared to better housing quality. Improving the housing stock could be considered a product of an economic development program, but it will be also impact future adaptation costs.

CLIMATE FORECASTING CAPABILITIES AND HAZARD MITIGATION SPENDING

Why are issues of model accuracy, environmental data adequacy, the status of national adaptation programs, and economic analyses relevant? If the scientific community cannot provide the levels of accuracy and detail required for effective hazard definition and analysis, then the global community runs the risk of wasting substantial amounts of limited adaptation aid funding. In fact, with a substantively inaccurate climate forecast used to build hazard mitigation structures, it is possible that we could make some climate change adaptation problems worse.

Expected Areas of Greatest Capital Investment

Whatever amounts of money are allocated by wealthier nations, the bulk of those funds in the next few decades will likely be spent on structural programs for hazard management (dams, levees, hurricane barriers, water supply management systems, etc) over the next few decades. Ten of the 15 largest cities in the developing world – including Shanghai, Mumbai and Cairo – are currently vulnerable to coastal storm surges and/or riverine flooding. In addition, the floodplains of the great rivers in South and East Asia are filled with people and cities that are variably protected from environmental hazards within the current climate typical for each location. In those areas, past attention to natural hazard mitigation has often been seconded to other, more critical social needs. Whether the current protection systems are adequate or not, preparation for projected climate changes means that we will have to bring the entire system up to a new – and as yet undefined – standard. In any number of cases, a global adaptation program for developing nations may include full construction of natural hazard mitigation systems, not just improvements. With an uncertain climatic future, structural options may be one of the primary sinks for capital expenditures and they may also represent one of the greater risks for inefficient allocation of development capital.

[As a cost reference, the US Army Corps of Engineers (2008) estimates that basic improvements to the levee system in New Orleans (just the levee improvements for one city before the effects of climate change are considered) will cost approximately $15 Billion to complete. The barriers and levees were originally designed to manage the expected impacts of a category 3 hurricane. Some portions of the city could see a >8 foot increase in storm surge potential between a category four and five hurricane. An increase in the severity and frequency of Gulf hurricanes would suggest the need for vast additional expenditures in order to improve the protective capabilities of the levee system.]

A focus on structural protection against natural hazards does not exclude the importance of non-structural alternatives like building flood-proofing, land use restrictions, insurance, modified construction standards, etc. Often, these programs can be far more efficient in reducing natural hazard losses and they should be an integral part of any comprehensive hazard management plan. Given the uncertainties of expected climate change, non-structural options may well be the first priority in mitigating poorly understood hazards.

The Relationship of Hazard Magnitude, Frequency and Cost

In hazard mitigation structural design, structures are built to a design standard. That standard is informed by a valuation of the assets requiring protection (people, structures and economic activity). If we do not understand the physical dimensions and probabilities of a hazard, then we run the risk of over or under-design. Forecasting uncertainty can be translated into structural elevation uncertainty. If the level of protection is too low (a levee is undersized, for example) then the structure will be overtopped with greater frequency and damages in excess of expectations will be experienced. It is not unusual to find that an under-designed structure will actually attract settlement and economic activity because of the illusion of safety. In those cases, the structure can actually increase the damages from natural hazards. In addition, a failure to properly protect an area from natural hazards may also undermine other investments in economic development. If the level of protection is too high, substantial sums may be wasted in construction with little or no additional benefit. **Better estimates of climatic variability translate into better allocations of aid and more efficient expenditures of available funds.**

Cost – Efficiency, Benefit Cost or Risk-Based Analysis

We need to be both careful and thoughtful in allocating resources to address current and possible future problems associated with climate change. *These uncertainties do not immediately imply that all efforts to manage developing nation environmental risk should cease.* It does suggest that such efforts be approached with a good deal of caution and forethought. The method for addressing the adaptation issue is not a simple matter of international obligation. Our nation has agreed to apply the "precautionary approach" in matters like these. The precautionary approach is defined in the Rio Declaration of 1992 (Principal 15 as endorsed by the United States), and it states that: "in order to protect the environment, the precautionary approach shall be widely applied by States (read signatory nations) according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation." The reader might note the phrase "cost-effective measures" in that declaration, as it should have implications for any adaptation aid forthcoming from the United States.

The US will want to maximize returns on any aid investments made to developing nations. Whether cost-efficiency (lowest-cost options for achieving supply of key services), cost-benefit (including some cost associated with loss of life) or risk-based (achieve an acceptable risk at a minimum cost) analyses are used, the analytical and policy-making challenge remains the same: efficient allocation of limited climate change funding in the face of a substantively uncertain climatic future. (It should be noted that the selection of screening and evaluative tools by each developing nation will reflect the cultural values of that nation. Assignation of value for human life will be a key determinant in the justification of many hazard control structures and programs.) Unless the US joins a group of funding nations and opts to lose direct control of investment, all US investments should be based on a thoughtful analysis of each planned project with careful quantitative attention to the risks associated with climatic and analytic data uncertainties.

SUMMARY AND RECOMMENDATIONS

Over the last decade, as more information has accumulated regarding the issue of climate change and as we better understand the potential environmental and economic impacts associated with such changes, there has been a growing call for immediate action to prepare for the effects of coming climate changes in developing nations. At the same time, we are experiencing a significant economic contraction within the global economy. Although some nations – especially China – are experiencing rapid economic growth, most of the developed nations are experiencing sluggish growth at best, and many of the developed nations face substantial amounts of accumulated deficits and under-funded future obligations that are impacting efforts to encourage economic expansion. Managing and reducing carbon emissions is a politically charged issue in the US, in part because a transition to a low-carbon economy has the potential to significantly impact elements of domestic economic activity. Allocation of additional aid dollars will come at some domestic cost, and we need to use care to maximize generated benefits on such investments.

The US has already committed to adaptation aid – both in concept and in treaty. We are also committed to the best use of limited aid dollars. There are a number of potential issues that should be addressed carefully in aid decisions:

- Significant uncertainties in longer-term climate forecasts
- A lack of regionally specific forecasts for many regions of the world
- In a number of developing nations, limited historic climatic and hydrologic data

When developing structural natural hazard mitigation programs – the likely area of greatest adaptation aid investment – poor forecasts and inadequate historical climate data can cause structural design error. Design errors either cause substantial cost overruns or higher than anticipated damages. The uncertainties we see in the data are in part reflected in the substantial variations in expected climate change adaptation costs seen in a number of loss projection analyses.

If funds are to be invested in any given project, a careful economic and risk-management analysis should be performed, and projects should be screened and funded based on their ability to meet a broad set of criteria, including:

- Consideration of a wide range of potential climatic outcomes over the life of the proposed project
- Definition of a range-of-choice for hazard management
- Quantified analysis of both risk-reduction and cost-efficiency associated with selected options
- First attention and priority to risk reduction before structural options are pursued
- Structural design proposals that include contingency plans for unanticipated climatic evolutions

In addition to direct financial aid, there may be several opportunities for indirect adaptation assistance. Climate forecast uncertainty and data limitations represent a critical choke point for definition of hazard mitigation programs. There is substantial international scientific attention to try and improve the quality and utility of such forecasts, but substantive improvements are probably a decade off (author's estimate). The US might consider developing an assistance center for climate/hydrology/hurricane science that develops the best and most current forecasting and analytical scientific services to support the development of a proposal for developing nation adaptation support. This would provide some continuity in proposals which would improve the aid proposal evaluation process. It would also employ domestic scientists while providing a politically stable platform for future adaptation analysis. Similar support could be offered for land use planning, non-structural engineering services and economic impact evaluation. Finally, the substantive climatic uncertainty may be partially managed by an insurance fund that offsets a specific fraction of the risks associated with adaptation.

Lastly, the US should give careful consideration to timing of adaptation investments. I think it would be safe to observe that we face maximum uncertainty at the present, and additional research and data collection should act to reduce uncertainty. That would suggest that first adaptation investments focus on analysis and modeling, followed by a heavier investment in non-structural adaptation programs with particular attention to minimizing future at-risk development (don't make the current problems worse).

Should the Committee wish to evaluate elements of this report in greater detail, I will be happy to support such efforts.

Redmond Clark, PhD

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